The onset of the southwest monsoon in 1990

R. Ananthakrishnan and M. K. Soman

Statistics relating to the date of onset of the southwest monsoon over Kerala for the 100-year period 1891–1990 reveal that the mean and median dates of onset for south Kerala are 31 May and 1 June, with a standard deviation of 8.5 days. Declaring the date of monsoon onset is not a straightforward matter. However, rainfall pattern, upper air circulation features and INSAT cloud pictures are useful guides, and these indicate that the onset date in 1990 was 17–18 May. During 1891–1990 there have been only 12 years in which the date of onset over Kerala has been on or before 18 May.

BECAUSE of its profound impact on the national economy, the southwest monsoon is by far the most important event in Indian meteorology and more studies have been devoted to understand the various facets of this unique phenomenon than for any other feature of the weather and climate of India. The onset of monsoon, with its bounty of rainfall over the country during a period of 4 months, comes as a welcome relief after the hot summer months. Traditionally the date of onset of monsoon is taken as the date when the first impact of monsoon rains is experienced over the state of Kerala at the extreme southwest of peninsular India. This impact, which can often be spectacular, is known as the 'burst of the monsoon'. While Kerala experiences rain in the form of what is known as 'premonsoon thunderstorms' prior to onset of monsoon, there is a distinct change in wind circulation, sky conditions and pattern of rainfall with onset of monsoon.

Date of monsoon onset

There is variation in the date of onset of monsoon from year to year. The range of onset date spans a period of over 40 days in May and June. However, the event is not randomly distributed over this interval. There is a clustering of the event around 1 June, clearly brought out when onset dates over a long period of years are examined. Figure 1, a histogram of the dates of monsoon onset over south Kerala in three-day intervals from 5 May to 24 June for the 100-year period 1891–1990, shows that the dates of onset for the individual years fall in this interval, the extreme dates being 7 May in 1918 and 22 June in 1972. The clustering of the dates of onset towards end May–early June is clearly brought out. The data used for Figure 1 are based on a recent study of ours[1] that made use of relevant records of the India Meteorological Department (IMD). On the basis of the data for 100 years the mean and median dates of onset for south Kerala are 31 May and 1 June, with a standard deviation of 8.5 days. For north Kerala the onset date is generally a day or two later than for south Kerala. The monsoon rains progress from south to north along the west coast, reaching Bombay on the average about 10 days after onset over Kerala.

Years in which the dates of monsoon onset are earlier/later than the long-term mean onset date by more than one standard deviation are regarded as years

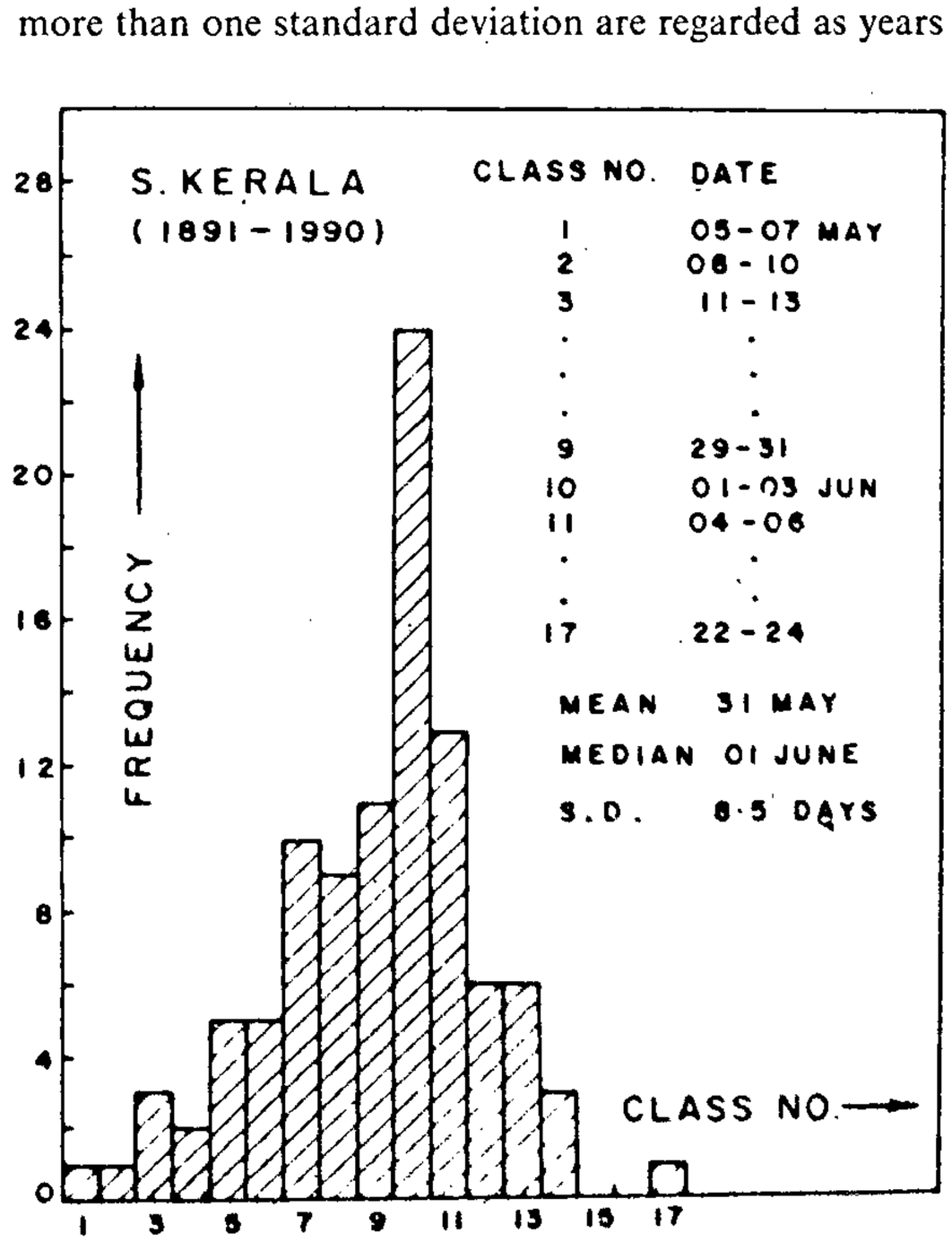

Figure 1. Histogram in three-day intervals of dates of onset of southwest monsoon over south Kerala for the period 1891–1990.

The authors are in the Indian Institute of Tropical Meteorology, Pune 411 008.

of early/late monsoon onset. Such years in the 100-year period for south Kerala number 17 and 10 respectively. Thus, in 73 years out of 100, the date of onset has been between 23 May and 9 June.

The mean date of monsoon onset for Kerala as a whole, which is around 1 June according to meteorological records, coincides almost exactly with the middle of the Malayalam month of *Edavam*, which is the tenth month of the Kollam era of the Kerala regional calendar. Traditionally the southwest monsoon is known in Kerala as *Edavapadi*, which literally means the middle of the month of Edavam. This shows that the near-regularity of the onset of the southwest monsoon around 1 June was known to the people of Kerala from very ancient times.

Prediction of the date of onset

There are no dynamical-numerical methods to enable prediction of the date of monsoon onset in individual years. All available methods are of a statistical nature and based on regression equations that use past data with selected antecedent parameters (surface and upper air) as predictors. Such equations are useful but are subject to the limitations that statistical prediction methods have.

Declaring the date of onset

Even declaration of the date of monsoon onset where no prediction is involved is not a straightforward and simple matter for which objective criteria are available. This may appear surprising considering the fact that IMD has been declaring the date of monsoon onset year after year for over a century. The difficulty arises from the fact that the circumstances associated with monsoon onset are not identical from one year to another. The onset of monsoon over Kerala is not a transition from a regime of no rain to one of rain; it is a transition from a regime of sporadic rainfall associated with the premonsoon thunderstorm season to one of spatially organized and temporally sustained rainfall associated with the monsoon. The transition can be sudden and spectacular in some years but less pronounced in other years. Nevertheless, there is a distinct change in rainfall pattern with onset of monsoon. This feature is strikingly brought out by the technique of superposed epoch analysis of daily rainfall data for several years[1,2].

Along with the change in the spatial and temporal distribution of rainfall, onset of monsoon is accompanied by changes in sky conditions, the state of the sea off the Kerala coast, and changes in upper air circulation. In recent decades photographs of cloud systems covering vast areas of land and sea transmitted by polar-orbiting and geostationary meteorological satellites have been an additional powerful tool for weather analysis and prognosis.

Long before upper-air observations became available and the weather satellite was not even a dream, dates of onset of monsoon had to be decided from only land-based observations, in which rainfall had the primary place. This continues to be so even today since, to the ordinary person, and especially to the farmer, monsoon is more or less synonymous with rainfall. Along with the rainfall are associated several other atmospheric features that the meteorologist is aware of, but these are not of concern to several agencies whose interest in weather information and forecasts is rainfall. Hence, in declaring the date of monsoon onset, a sustained increase in rainfall at a network of spatially distributed stations is accorded prime importance, although its quantification is difficult. This leads to some degree of subjectivity in declaring the date of monsoon onset, particularly in those years in which the onset is less spectacular. In general, the professional forecaster exercises a measure of caution and watches the situation for a day or two before declaring the date of monsoon onset. On account of this, a 'post-mortem' examination of the data will show, that, for many years, the onset date can be fixed one or two days before the officially announced onset date.

At the beginning of his book *Monsoon Meteorology* Ramage[3] gives an interesting quotation from the writings of Jawaharlal Nehru about his experience of watching the arrival of the monsoon rains at Bombay in a particular year.

> I had been told and I had read that this coming of the first rains was an event in Bombay; they came with pomp and circumstance and overwhelmed the city with their lavish gift.... Bombay was not static then; it became elemental, dynamic, changing.
>
> So I looked forward to the coming of the monsoon and I became a watcher of the skies, waiting to spot the herald that preceded the attack. A few showers came. Oh, that was nothing, I was told; the monsoon has yet to come. Heavier rains followed, but I ignored them and waited for some extraordinary happening. While I waited I learnt from various people that the monsoon had come and established itself.... Like the thief in the night the monsoon had come to Bombay, as well it might have done in Allahabad or elsewhere. Another illusion gone.

Nehru's experience of watching the onset of the southwest monsoon rains over Bombay in a particular year should not be generalized. There are many years in which the onset of monsoon rains along the west coast of India can be spectacular. One such example is the onset of the southwest monsoon over Kerala in 1990. Here we present the meteorological features associated with the 1990 monsoon onset from three different angles: rainfall, upper air circulation, and INSAT cloud pictures.

Table 1. Daily rainfall in mm from 1 May to 31 May 1990 at three island and eight coastal stations.

Date	MNC	AGY	AMN	TRV	ALP	CHN	CLT	CNR	MNG	PNJ	BMB
1					3	1	9	1	5		
2				54	34	5					
3				1							
4											
5							19	2			
6					38	6	57				
7				32	28	18	13		3		
8				4	9	17					
9				2	3	8	7	3	1		
10				1	13	4	41	23			
11				T	1	8	4	22	13		
12				6			7	7		T	
13					4					1	
14											
15											
16										1	
17*(SK)	11			36	18	5	1				
18*(NK)	12	70	15	44	66	146	15	168	1		
19	5	2	T	24	18	4	44	31	T	17	
20	42	20	41	47	17	9	80	31	2	8	
21	22	55	29	8	36	33	40	99	113	11	4
22	4	4	12	1	18	10	5	3	28	29	T
23		4	2	2	21	21	9	1	5	T	3
24	7	23	11	3	34	56	36	11	56	2	1
25	19	20	16	T	25	20	151	39	101	6	
26	20	52	24	26	35	71	80	38	6	29	T
27	8	13	45	8	41	28	44	34	23	68	29
28	1		7	5	22	6	18	19	74	103	
29	1	NA	6	3	26	17	49	36	106	54	3
30	12	NA	9	1	40	44	15	31	28	26	1
31	8	6	3	10	14	25	59	73	51	37	89

Data from IMD records

*Onset date; SK, South Kerala; NK, North Kerala

T, < 1 mm rain; NA, data not available

Island stations: MNC, Minicoy; AGY, Agathy; AMN, Amini. Coastal stations: TRV, Trivandrum; ALP, Alleppey; CHN, Cochin; CLT, Calicut; CNR, Cannanore; MNG, Mangalore; PNJ, Panjim; BMB, Bombay.

Rainfall distribution

Table 1 and Figure 2 show that Kerala experienced a spell of rain, with some heavy falls, around 6–11 May. This occurred in association with a deep depression that originated in the southwest Bay of Bengal on 5 May, rapidly intensified into a severe cyclonic storm, and crossed the north Andhra coast near Masulipatnam on the evening of 9 May after skirting coastal Madras in the course of its travel. As we shall show in the next section, the upper air circulation over Kerala underwent an abrupt change during the period of the spell of rain. This was followed by a lull in the rainfall and weakening of the upper air circulation for the next five days.

On the morning of 16 May no station in Kerala recorded measurable amounts of rainfall (see Figure 3).

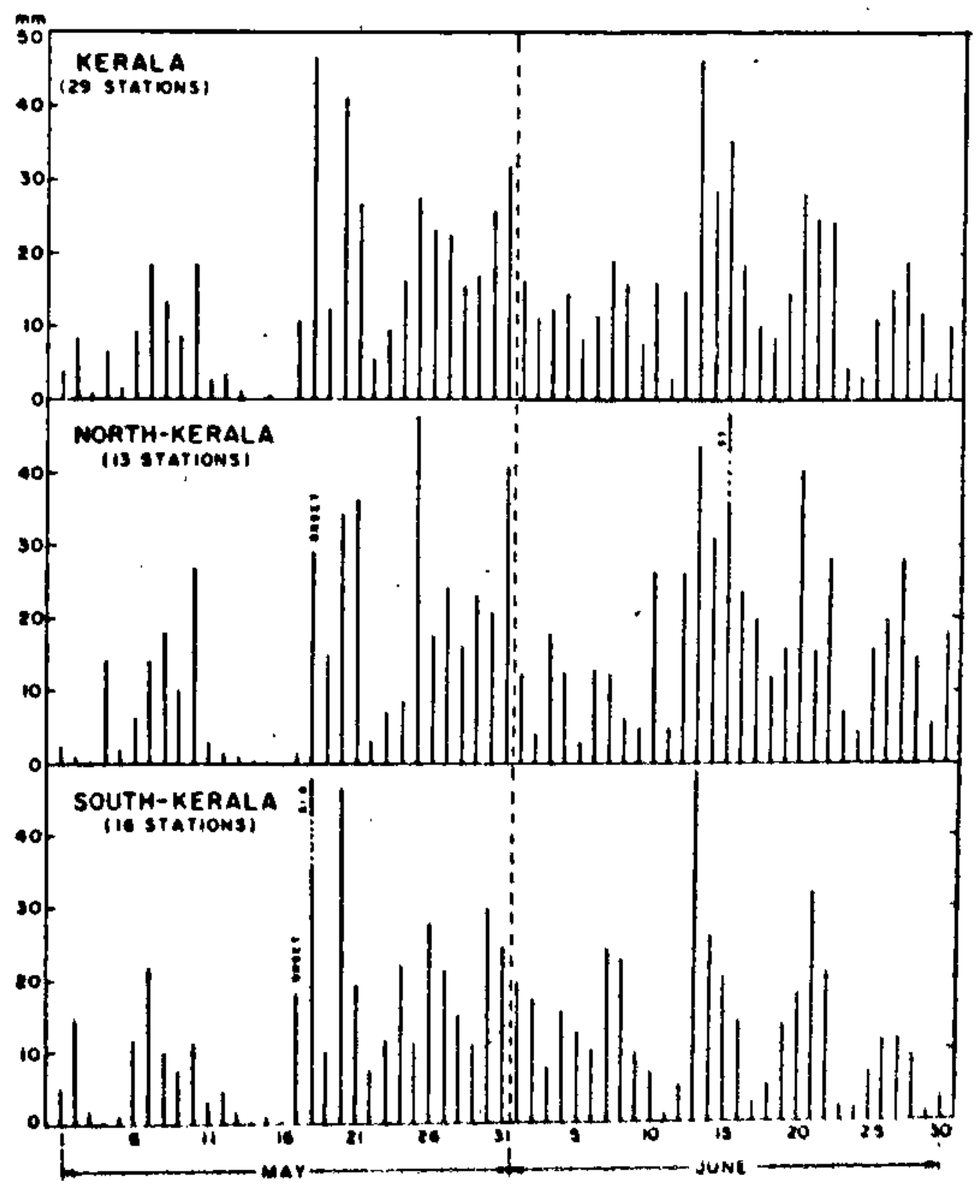

Figure 2. Area-averaged daily rainfall from 1 May to 30 June 1990 over south Kerala, north Kerala and Kerala as a whole. (Based on data furnished by the State Meteorological Centre, Trivandrum)

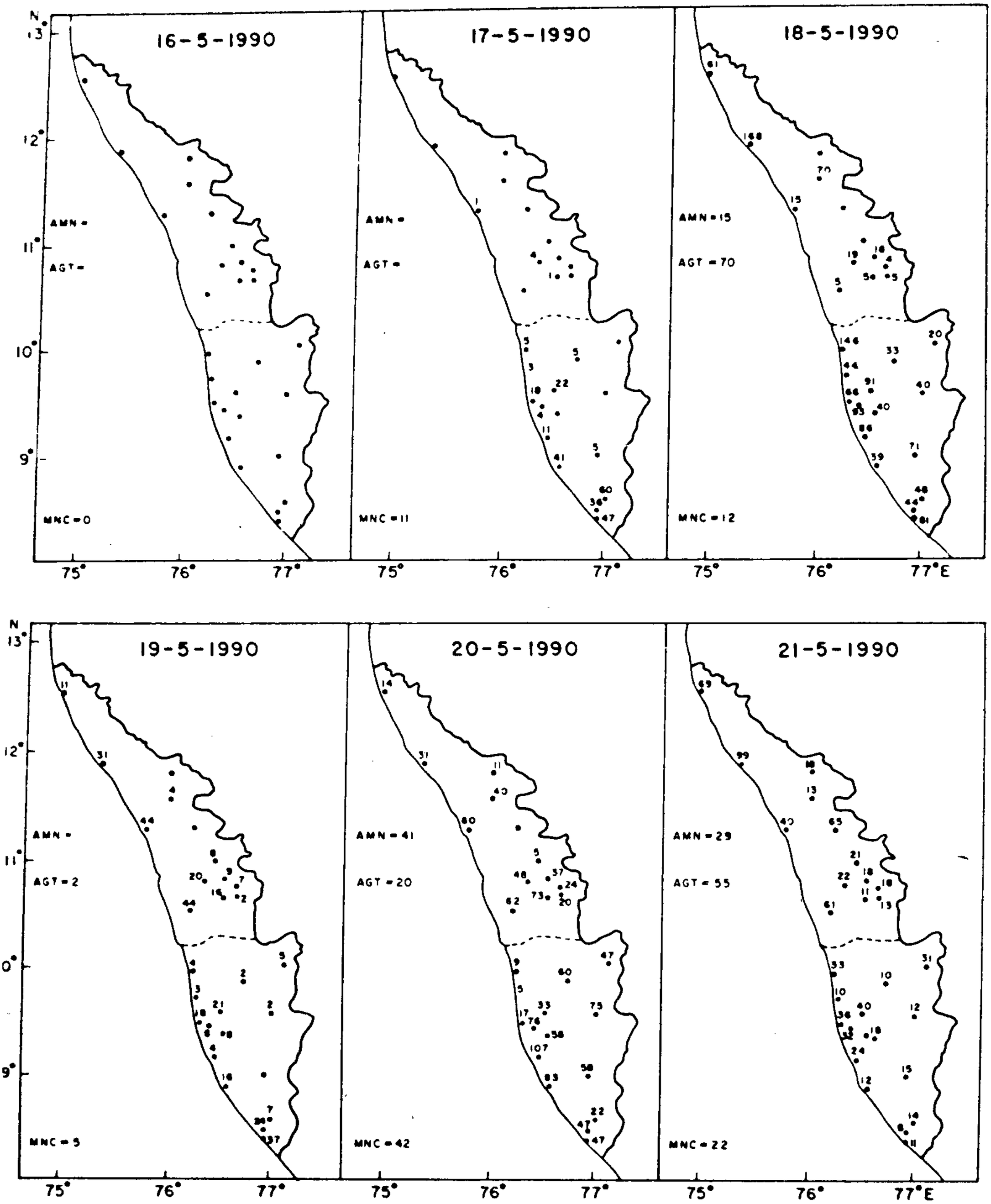

Figure 3. Daily rainfall distribution over Kerala (in mm) from 16 May to 21 May 1990. The longitudes of the three island stations are further west than shown on the diagrams. (Based on data furnished by the State Meteorological Centre, Trivandrum)

Nearly the same situation obtained during the preceding three or four days. A sudden change can be noticed from 16 to 17 May. All stations in south Kerala recorded rainfall on the morning of 17 May, with some stations in the extreme south, including Trivandrum, recording about 4 to 6 cm of rain, while north Kerala was nearly dry. (The rainfall reported for any day is the amount of rain during the preceding 24 hours ending at 0830 hrs IST of the day in question.)

A spectacular change can be seen from 17 to 18 May. All the Kerala stations recorded rainfall, with nearly 15 cm at Cochin and 17 cm at Cannanore in the north. Widespread rain continued to occur over Kerala for the next three days—19, 20 and 21 May. The sequence of average daily rainfall over the state can be seen from Figure 2, while daily rainfall at selected observatory stations (island and coastal) can be seen from Table 1. Note that rainfall at the island stations commenced simultaneously with rainfall at Kerala stations. (There was no rain at the island stations in association with the earlier spell of rain caused by the Andhra cyclone.)

One of the *Forecasting Manual* publications[4] of IMD is devoted to examination of the sequence of daily rainfall from 1 May to 30 June for the years 1901 to 1965 at some of the southern coastal and island stations in relation to the date of onset of the southwest monsoon over Kerala. The aim was to see whether some kind of semi-objective criteria could be identified that might serve as guide for operational forecasters. Some empirical guidelines have been given in that publication. More recently we have examined this problem in greater depth using the area-averaged daily rainfall at 75 rain-gauge stations distributed over south and north Kerala. Our study, which covered the period 1901–1980, showed that onset of monsoon is characterized by a distinct and substantial increase in the area-averaged rainfall, for which we identified a threshold of 1 cm. On the basis of the criteria that we have set out in our paper[1], the date of onset of southwest monsoon over south Kerala in 1990 is 17 May and that over north Kerala 18 May. These dates are indicated in Table 1 and Figure 2. The onset date for Kerala originally given as 28 May in the daily and weekly weather reports has been revised as 19 May in the weather summary for the summer monsoon season of 1990 published by IMD[5].

From private communications we came to know that the monsoon 'came with a bang' at Cochin on 17 May—what Nehru was looking for while watching the skies in Bombay. It was also understood that the heavy rains during the first few days after onset caused flooding of rice fields in Kerala. Rainfall progression at the island stations in the Arabian Sea and at the coastal observatory stations from Trivandrum to Bombay following onset over Kerala on 17–18 May can be seen from Table 1. By ten days following onset, rainfall had reached Bombay.

Upper air circulation features

As stated earlier, the onset of the southwest monsoon is accompanied by significant changes in the upper air circulation features. This is illustrated by Figure 4, in which are shown isopleths of the kinetic energy of the zonal (east–west) component of the air flow over Trivandrum based on daily morning radio-wind measurements from 1 May to 31 May 1990. A sharp increase in strength and deepening of the zonal westerlies occurred between 6 and 10 May in association with the cyclonic storm mentioned earlier, followed by a weakening and decrease in depth during the next five days. From 16 May there was again a rapid increase in strength and deepening of the westerlies accompanying monsoon onset. The depth of the westerlies remained above 500-mb level thereafter, with fluctuations in strength. In Figure 4 two epochs of zonal kinetic energy maximum between 800-mb and 700-mb levels (height from ground 2 to 3 km) can be identified around 20 and 28 May. The kinetic energy of the upper tropospheric easterlies around 150-mb level (~ 14.5 km) also shows strengthening at these epochs. Thus the circulation features also lend support to fixing the date of onset of the monsoon over Kerala as 17–18 May.

INSAT cloud pictures

Good INSAT pictures of cloud imagery in the visible and infrared obtained from IMD are available for all days of May 1990. Figure 5 shows pictures for selected dates covering the area of interest in connection with the present study. The first six pictures in Figure 5 are for 6, 7, 8, 9, 15 and 16 May. The progress of the cloud

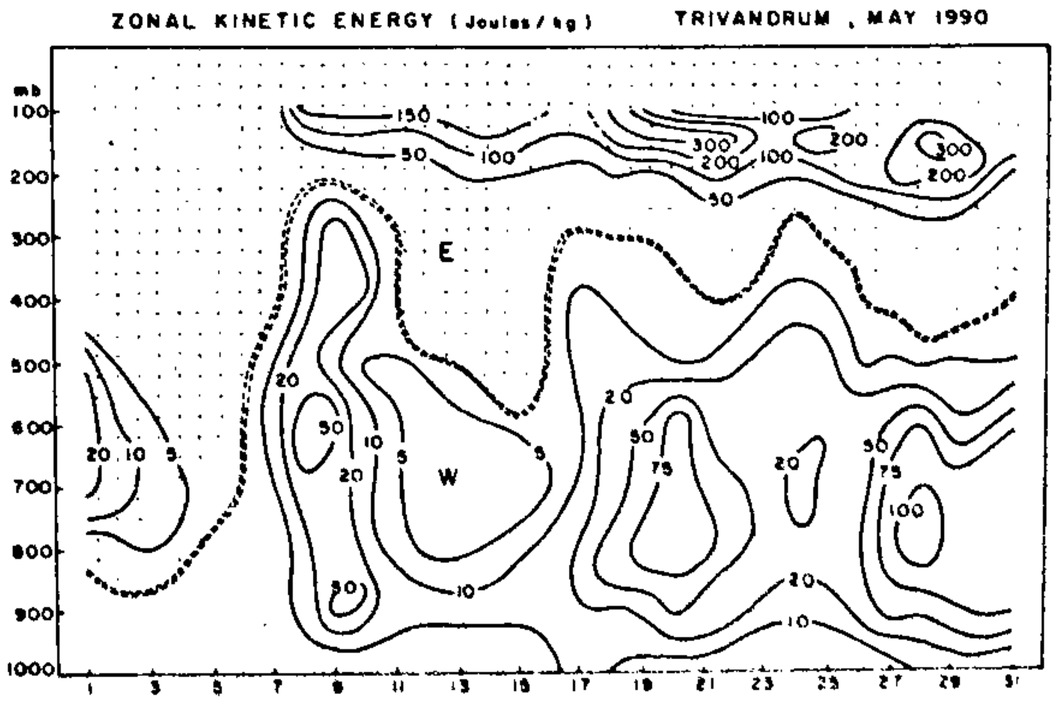

Figure 4. Vertical variation of the kinetic energy of zonal winds over Trivandrum from 1 May to 31 May 1990. The horizontal axis shows dates, and the vertical axis represents height from ground in decreasing magnitude of pressure in millibars (mb). The regimes of the zonal westerlies (W) of the lower levels and the zonal easterlies (E) of the upper levels are demarcated.

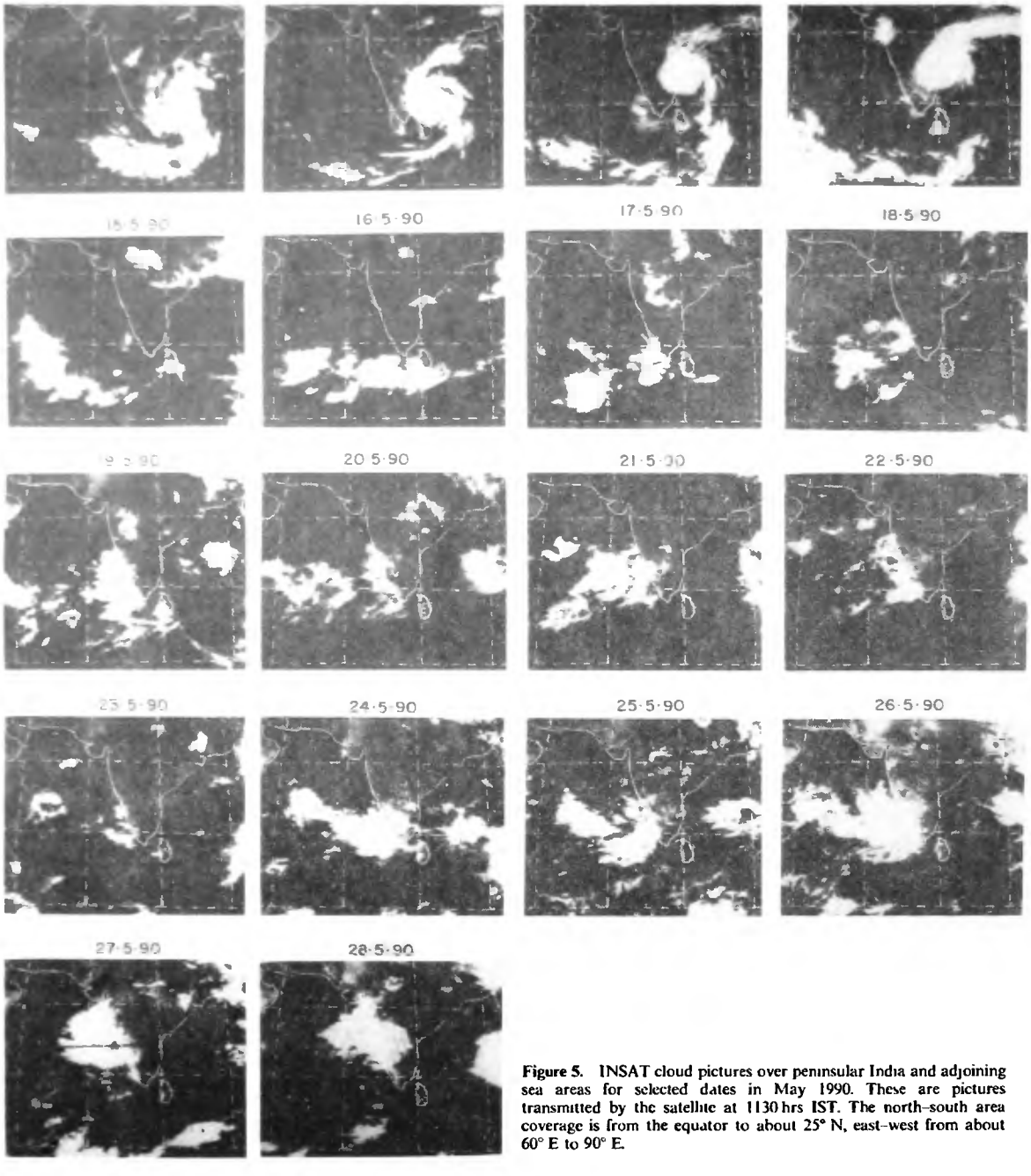

Figure 5. INSAT cloud pictures over peninsular India and adjoining sea areas for selected dates in May 1990. These are pictures transmitted by the satellite at 1130 hrs IST. The north–south area coverage is from the equator to about 25° N, east–west from about 60° E to 90° E.

system associated with the Andhra cyclone can be seen from the first four pictures. The next two pictures, for 15 and 16 May, show that Kerala was cloud-free on these two dates. A dense, zonally oriented cloud band is seen south of the tip of the peninsula in the last picture.

The next six pictures are for the sequence of days from 17 to 22 May. The significant change from 16 to 17 is the massive cloud over Kerala and the adjoining sea area. A progressively northward extension of the cloud system along the west coast and adjoining sea areas can be seen from 17 to 22 May. Table 1 shows a corresponding extension of the rainfall up to Goa.

The last six pictures show the sequence from 23 to 28 May. Some decrease in clouding can be noted on 23

May. This was followed by the development of a massive cloud system on the next day, which had extended beyond Bombay by 28 May. The associated rainfall at the island and coastal stations can be seen from Table 1. As one expects, the formation and movement of the cloud system from 17 to 28 May are in consonance with the rainfall progression and the associated circulation features during the period.

Conclusion

The evidence presented here on the basis of rainfall, circulation features and INSAT cloud pictures shows that 1990 was *a year of early monsoon onset* over Kerala. Taking Kerala as a single meteorological subdivision, as in IMD practice, the date of onset is 17 May marginally and 18 May with certainty. In the 100 years from 1891 there have been only 12 years in which the onset date has been on or before 18 May. Apart from the early onset, 1990 was also a year of typical 'burst of the southwest monsoon' over Kerala preceded by days of little or no rainfall.

1. Ananthakrishnan, R. and Soman, M. K., *J. Climatol.*, 1988, **8**, 283–296.
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5. Gupta, G. R., Desai, D. S. and Biswas, N. C., *Mausam*, 1991, **42**, 309–328.

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MEETINGS/SYMPOSIA/SEMINARS

International Conference on the Chemistry of the Atmosphere: Its Impact on Global Change

Place: Baltimore, USA
Date: 2–6 December 1991

Sponsored by the International Union of Pure and Applied Chemistry, co-sponsored by the American Chemical Society in association with the National Academy of Sciences and the Third World Academy of Sciences

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Place: Agra
Date: 9–12 December 1991

There will also be a symposium on radioimmunotargeting and radionuclides in the diagnosis of infection and a joint session with the Indo-American Society of Nuclear Medicine.

Contact: Dr D. K. Hazra/Dr A. K. Gupta
Organizing Secretary, XXIII Annual Conference
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PG Department of Medicine
S. N. Medical College
Agra 282 003
Phone: (562) 73163, 75266, 72412, 65192
Telex: 565-216, 565-406
Fax: (562) 361146, 73376

Fifth National Conference on In-House R&D Industry

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Contact: Director,
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Place: Bombay
Date: 15-17 January 1992
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